DOE Peer Review
Washington, DC

Burns & McDonnell
Packaged Cooling, Heating & Power Systems for Buildings

December 2003

presented by

Rod Schwass, BCHP Project Director
Burns & McDonnell

Agenda

- Burns & McDonnell Team Overview
- Project Background
- Project Approach
- Project Site Overview
- Project Goals and Objectives
- BCHP Economic Analysis Model
- Project Schedule and Key Milestones

Burns & McDonnell Team Overview

Burns & McDonnell

Program Manager

- Founded in 1898
- Integrated design-build company
- 100% employee owned – over 1,700 employees
- More than 100 years expertise with energy generation projects
- 20 regional offices - projects worldwide

Solar Turbines Incorporated

Industrial Turbine Manufacturer

- Subsidiary of Caterpillar
- Leading U.S. supplier of industrial gas turbines ranging from 1 to 13 MW
- Proven technology with strong technical, research & development expertise
- Headquartered in San Diego with a global presence

Broad USA, Inc.

Absorption Chiller Manufacturer

- Worlds largest manufacturer of absorption chillers
- 1,200 units annually = over 500,000 tons with more than 6,000 units in operation
- The only dedicated manufacturer of absorption chillers with a 3.3 million ft^2 manufacturing facility
- Proven track record with the DOE

Austin Energy

Owner/Local Municipality

- Nation's 10th largest community-owned electric utility
- 360,000 customers
- 2,600 MW of total generation
- Very active renewable energy and energy efficiency programs

Turbine Air Systems

System Packager

- Experienced Packaged Chiller Plant Equipment for the Power Industry
- Over 100 Systems Installed with a Combined Capacity Near 250,000 Tons
- Modular, Compact & Portable
- Complete System - Chillers, Cooling Towers, Pumps, Electrical Motor Controls Centers and DDC Controls

Project Background

DOE/ORNL Solicitation

Statement of Work

Packaged and modular systems development focuses on innovative integration of on-site/near-site power generation and thermally activated systems to be incorporated into individual buildings.

DOE/ORNL Solicitation

Key Technical Areas

- Thermally activated technologies
  - Absorption cooling
  - Thermal heating
  - Humidity controls
- Onsite power technology
- Controls development
- Systems integration

DOE/ORNL Solicitation

Targeted Market

- Commercial buildings
- Institutional buildings
- Government facilities
- District energy systems that distribute thermal energy to:
  - College campuses
  - Hospital complexes
  - Industrial parks
  - Commercial campuses

DOE/ORNL Solicitation

Project Intent

- By **combining existing proven** technologies...
  - Determine if our approach is better than existing configurations
  - Determine the optimum configuration of the system
  - Develop a method to size a system for a specific load profile

Project Approach

Original System Concept

- Low emission gas turbine generator
- Two-stage co-gen absorption chiller using turbine exhaust
- Two-stage co-fired absorption chiller using natural gas and turbine exhaust
- Provide electricity, chilled water, and hot water

Project Approach

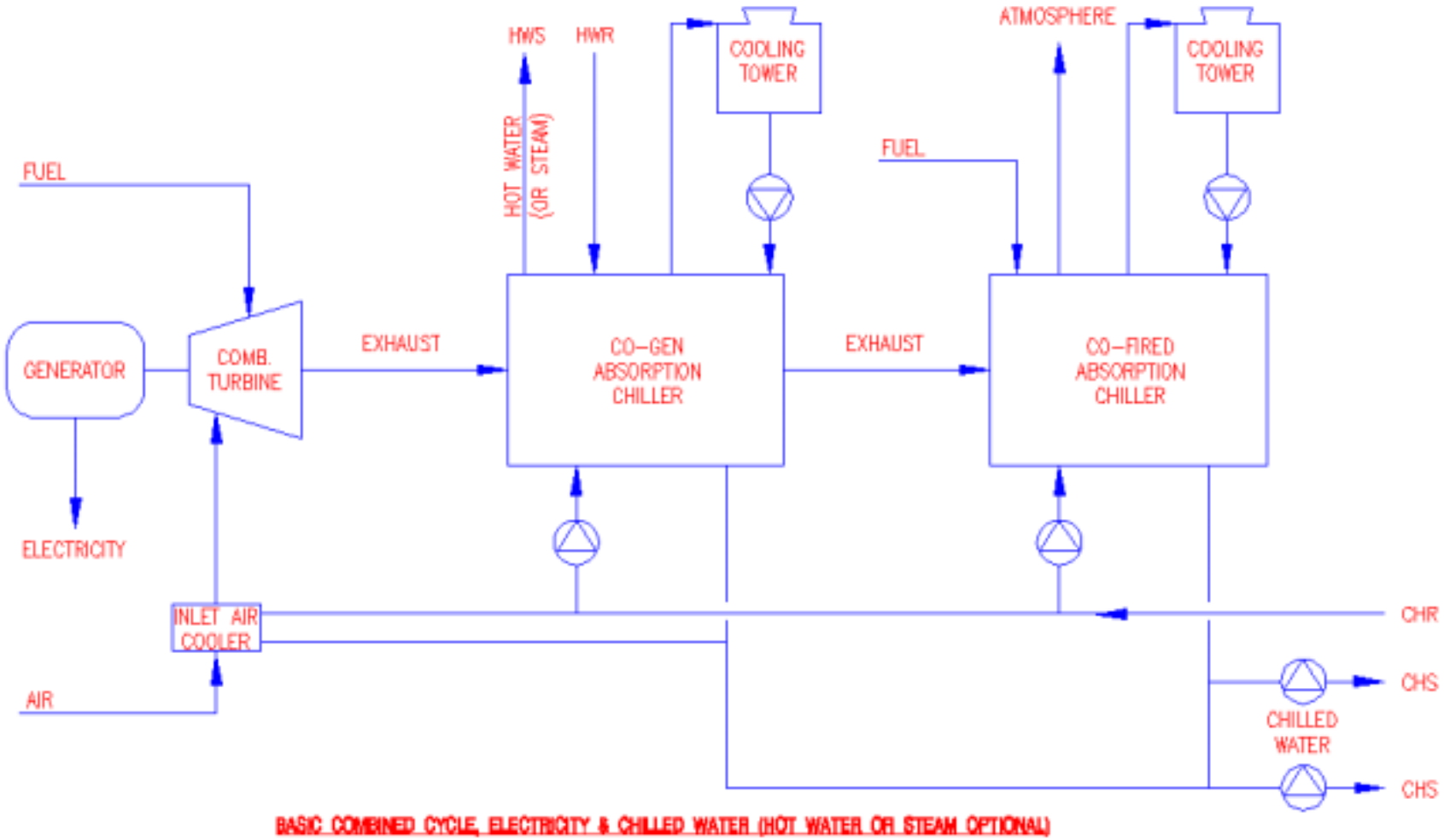
Site Selection Process

Site	Location	Score
Brooks AFB	San Antonio	483
UT Health Science	San Antonio	483
UT San Antonio	San Antonio	482
University of Iowa	Iowa City	473
Naval Med Center	San Diego	427
Carnegie-Mellon	Pittsburgh	355
Bunker Hill CC	Boston	307
North Island	San Diego	267

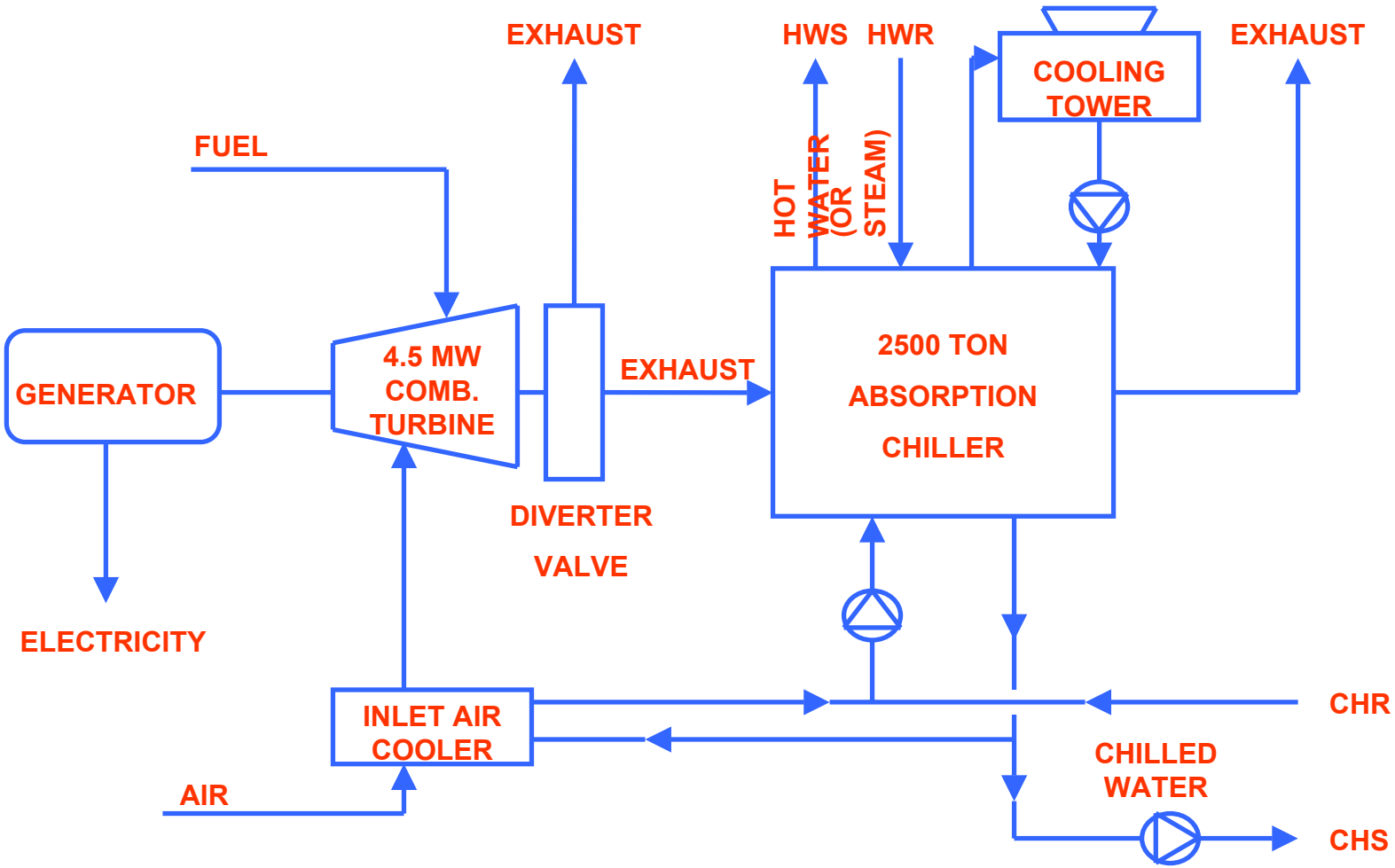
Project Approach

- Install IES in Austin, TX as part of The Domain
- Owner/Operator will be Austin Energy
- Integrate IES into existing chilled water system
- Interconnect to local substation with the ability to feed the electric grid

Original Concept Diagram



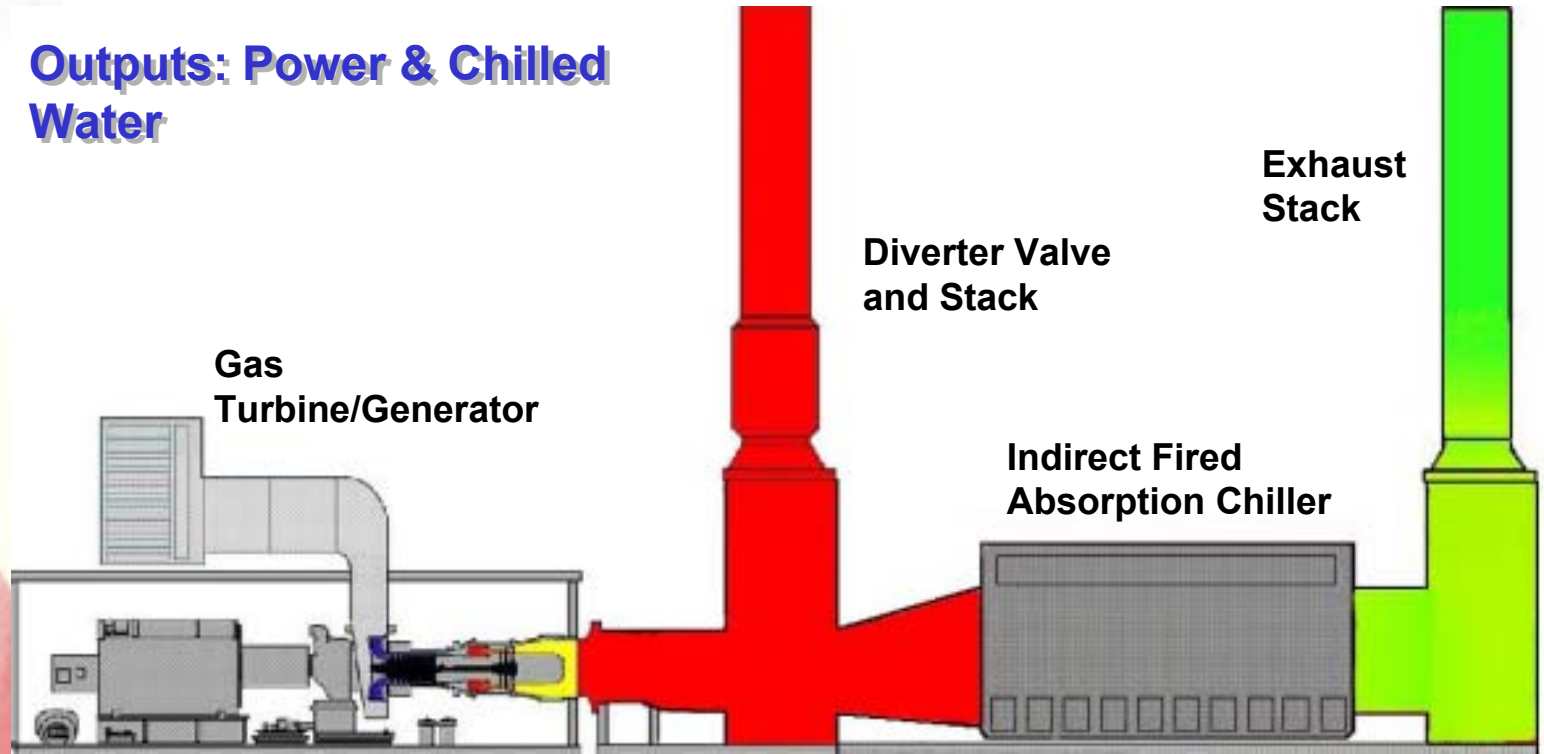
Current System Diagram



Current System Elevation

Gas Turbine Exhaust & Indirectly-Fired Absorption Chiller

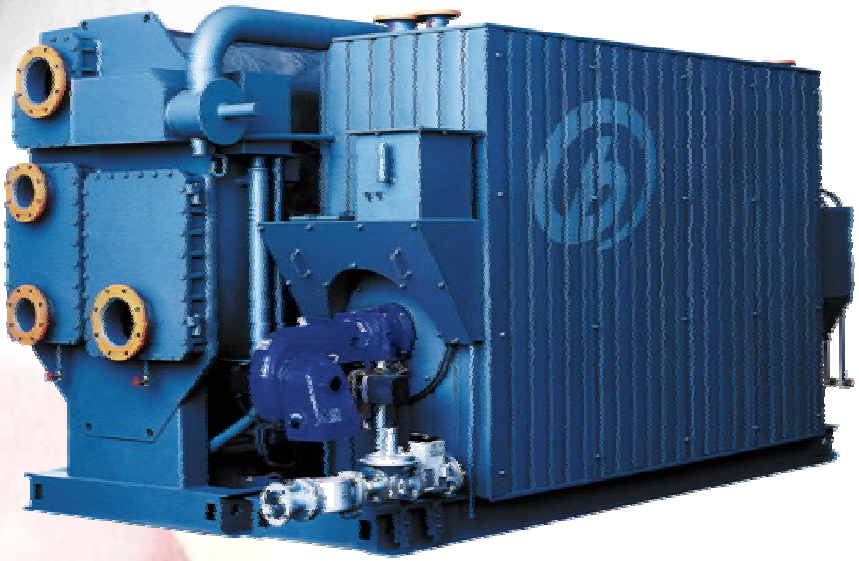
Outputs: Power & Chilled Water



Solar Turbines – Centaur 50

- Nameplate: 4.6 MW
- Exhaust: 950 ^{o}F
- Heat Rate: 11,630 LHV
- Low NOx: 15 ppm

Broad - Spectrum



- Co-Gen Absorber
  - 2,500 Tons
  - Fuel: Turbine Exhaust

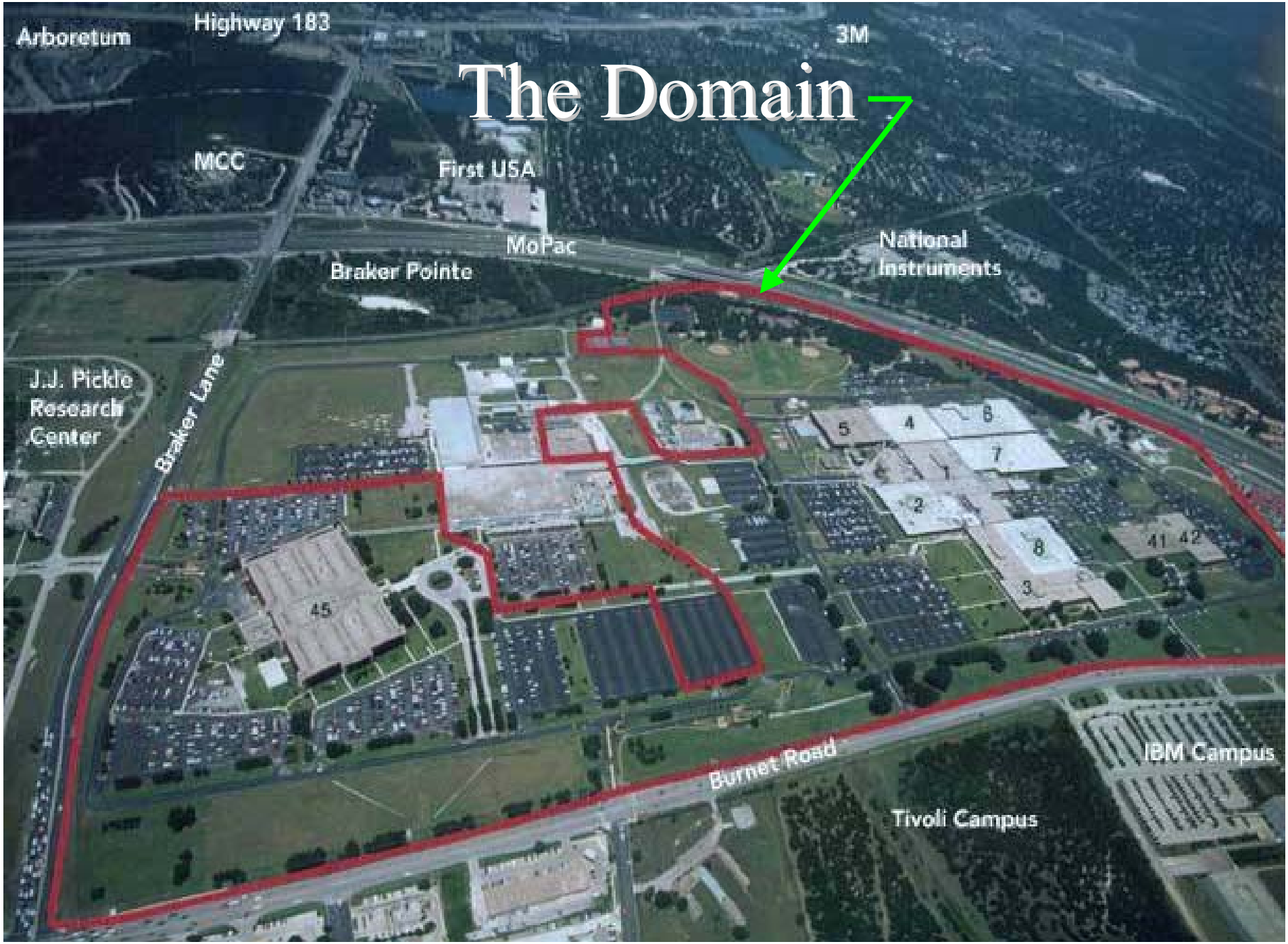
Turbine Air Systems

- Packaged Systems Include:
  - Natural Gas Compressor Skid
  - Inlet Air Filter Module
  - Process Controls Skid
  - Exhaust Stack

Proposed Controls Integration

- Austin Energy Domain Plant Has An Existing BACS
- Solar Turbine Has PLC Based Controls
- Broad Chiller PLC Based Controls
- Turbine Air System will Integrate PLC Based Controls Systems to the Existing Domain Plant BACS

Project Site Overview


Arboretum
Highway 183
3M
The Domain
MCC
First USA
MoPac
Braker Pointe
National Instruments
J.J. Pickle Research Center
Braker Lane
Burnet Road
IBM Campus
Tivoli Campus

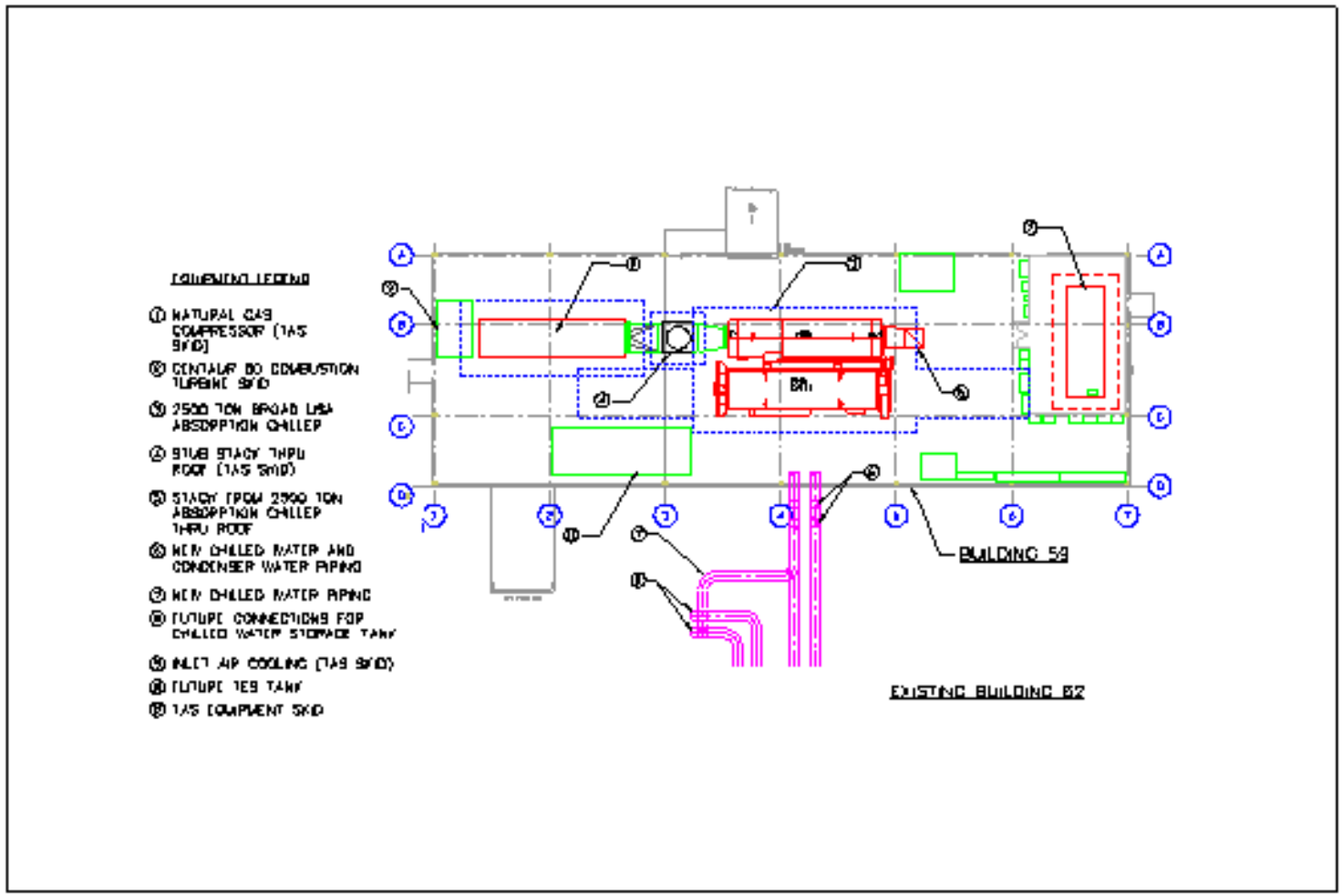

The Domain Central Utility Plant

End of Building 59 for Equipment Entry

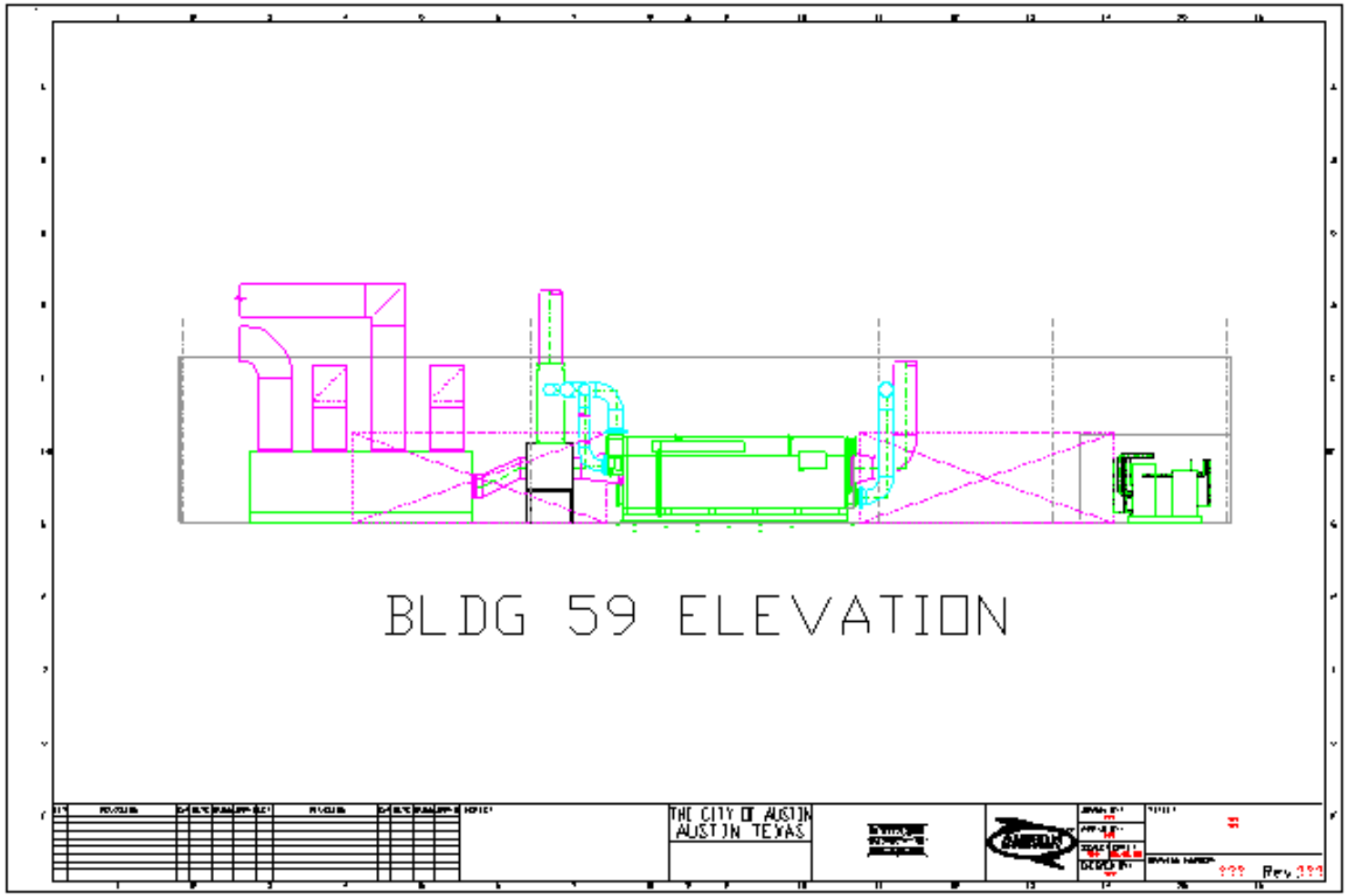
Space Between Bldg 59 and Bldg 62

Manholes in Substation for Tie-In Point

Building 59 Layout



Building 59 Elevation



Project Goals and Objectives

Goals and Objectives

- Energy uses for prototype system:
  - Electricity to local area and electric grid
  - Chilled water for air conditioning
  - Chilled water for inlet air cooling for gas turbine
- Anticipated efficiency > 70%
- Potential efficiency > 80%
- Savings through efficiency

Goals and Objectives

- 2,500 tons of co-gen cooling from generator exhaust that does not require additional fuel input
- Develop solutions for integration with building control systems
- Develop grid interconnection procedure with Austin Energy

Goals and Objectives

- Educational benefits through collaboration with The University of Texas School of Engineering
- Integrated control system that will allow ease of operations and remote monitoring
- Modular design will be adaptable to meet various capacity requirements and space limitations

Project Risks

- Economics
  - IES efficiency compared to traditional approaches
  - Must run turbine to get cheap cooling
  - Volatile natural gas market

Technical Issues

- Chilled water supply temperature
  - **Issue:** Absorber designed to operate most efficiently at a minimum chilled water supply temp of 44 degrees F. May be a need in the future to supply chilled water at a temp below 44 degrees F.
  - **Strategy:** Design will incorporate an alternate operational mode to provide pre-cooling.

BCHP Economic Analysis Model

CHP Economic Analysis Model

- Uses Multiple Standard Inputs
- Allows Initial Evaluation of On-Site Energy Systems Based on Minimal Information
- Allows for Rapid What-If Evaluation of Alternates
- Built In Sensitivity Allows for Significant Variations

CHP Economic Analysis Model

- Schedule of Generator Hours of Operation
- Models Combination of Chiller Types
- Accounts for Turbine Inlet Air Cooling
- Site-Specific Weather Bin Data
- Impact of Temperature Setbacks

CHP Economic Analysis Model

- Impact of Thermal Energy Storage
- Includes Various Escalations
- Calculates Annual Expenses, Annual Revenues, and Includes Investment Cost with or Without Salvage Value
- Accounts for Tax Impact
- Incorporates Financing Options

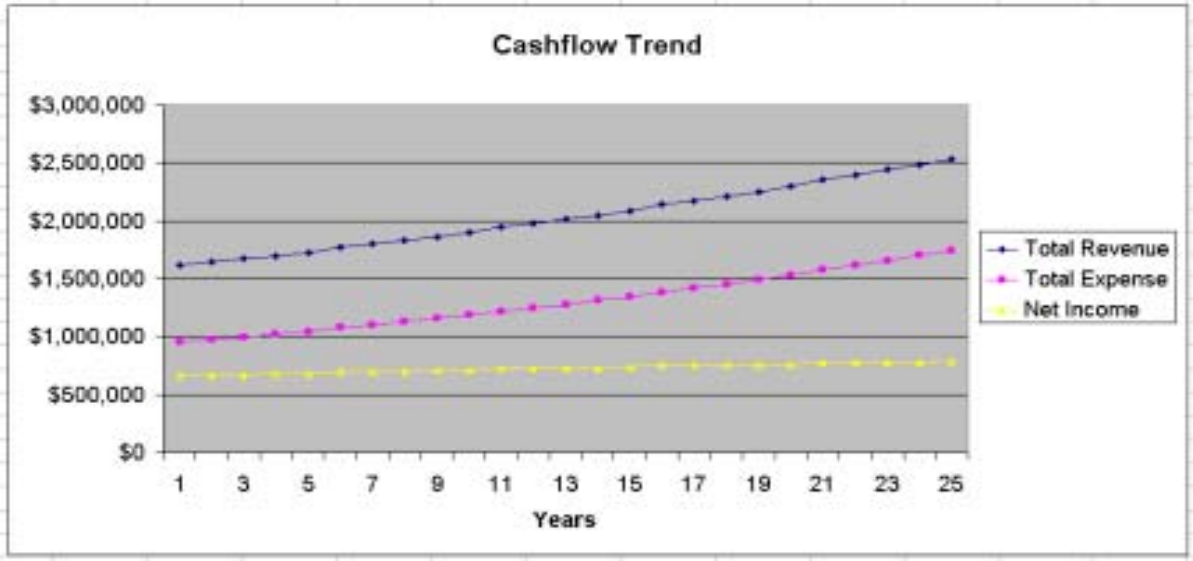
CHP Economic Analysis Model

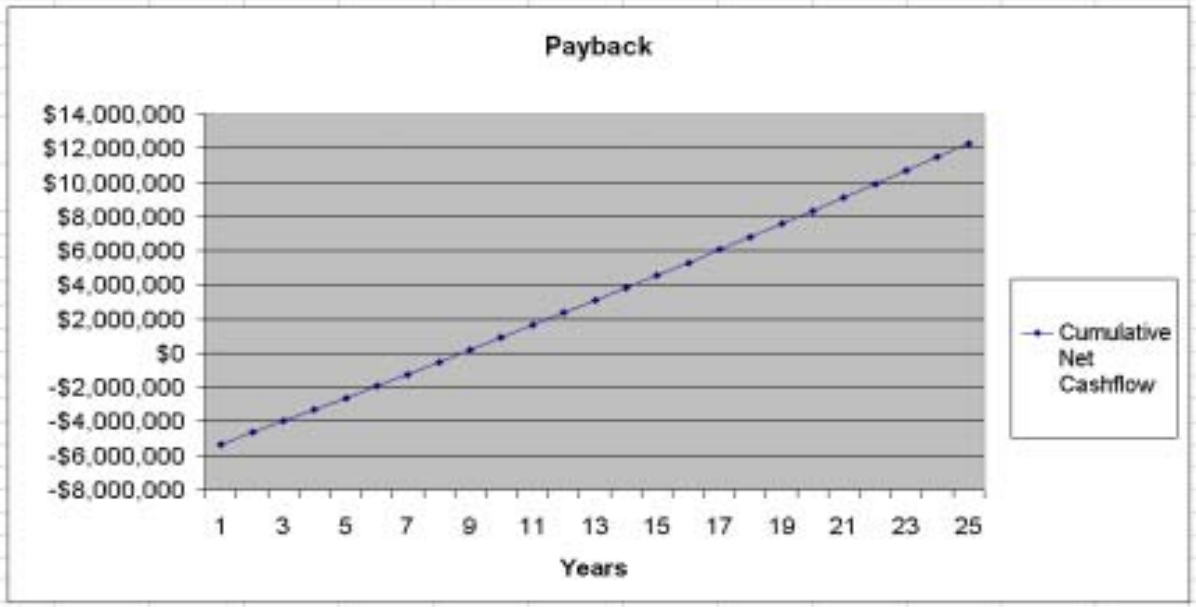
- Calculates Annual Cash Flow, NPV and IRR
- Provides Graphical Sensitivity Results for Range of NG Cost, Electricity Cost and Investment Cost

Sample Model Output

EXECUTIVE SUMMARY

INCOME ANALYSIS	Base Case 20 Years	NPV
Revenue		
Electric	$7,196,403	
Chilled Water	$15,166,230	
Boiler Fuel Savings*	$0	
Total Revenue	**$22,362,633**	
Expenses		
Engine Generator O&M**	$901,577	
Chiller O&M	$634,039	
Gas Expense - Eng. Gen	$10,381,310	
Elec Exp - Elec & BCHP Chillers	$1,990,305	
Gas Expense - DFA	$0	
Insurance & Other Expenses	$0	
Total Expenses	**$13,907,232**	
Net Income	**$8,455,401**	
CASHFLOW ANALYSIS		
Net Income	$8,455,401	
Depreciation	$0	
Interest Payment	$0	
Taxable Income	$8,455,401	
Income Tax	$0	
Principle Payment	$0	
Investment and Salvage	($5,000,000)	
Equity	$0	
Net Cashflow Before Taxes	**$8,455,401**	
Net Cashflow After Taxes - Debt	**$8,455,401**	
Net Cashflow After Taxes - Equity	**$8,455,401**	
NPV After Pay Investment	**$2,455,401**	
IRR Before Taxes	9.92%	
IRR After Taxes (Debt)	N.A.	
IRR After Taxes (Equity)	N.A.	
Payback Years	9.75	





Sample Model Output

EXECUTIVE SUMMARY DETAIL

INCOME ANALYSIS	Base Case 20 Years	NPV
Revenue		
Electric	$7,196,403	
Chilled Water	$15,166,230	
Boiler Fuel Savings*	$0	
Total Revenue	**$22,362,633**	
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Gas Expense - DFA	$0	
Insurance & Other Expenses	$0	
Total Expenses	**$13,907,232**	
Net Income	**$8,455,401**	

at	$0.055/kWh	and	3.0%	escalation every 5 years			
at	$0.138/Ton-Hr	and	2.5%	escalation annually			
at	$0.005/kWh	and	2.0%	escalation annually			
at	$0.006/Ton-Hr	and	2.5%	escalation annually			
at	$4.35/mmBtu	and	3.0%	escalation annually	and	0.0%	gas sensitivity
at	$0.055/kWh	and	3.0%	escalation every 5 years			
at	$4.35/mmBtu	and	3.0%	escalation annually	and	0.0%	gas sensitivity

IND Chiller Capacity, Tons	1,000
DFA Chiller Capacity, Tons	0
Average Elec Chiller Capacity, Tons	1,000
Peak Central Plant Tons	1,500
Peak Central Plant Heating Load, MMBtu	0

CASHFLOW ANALYSIS	
Net Income	$8,455,401
Depreciation	$0
Interest Payment	$0
Taxable Income	$8,455,401
Income Tax	$0
Principle Payment	$0
Investment and Salvage	($6,000,000)
Equity	$0
Net Cashflow Before Taxes	**$8,455,401**
Net Cashflow After Taxes - Debt	**$8,455,401**
Net Cashflow After Taxes - Equity	**$8,455,401**
NPV After Pay Investment	**$2,455,401**
IRR Before Taxes	**9.9%**
IRR After Taxes (Debt)	N.A.
IRR After Taxes (Equity)	N.A.
Payback Years	9.75

Annual % Utilization of BCHP	**67.17%**
Annual System Efficiency	**74.74%**
IES Efficiency per Hour	**74.33%**
Annual Ton Hours Cooling, Existing	6,289,998
Annual Ton Hours Cooling, Air Inlet	1,207,834
Annual Ton Hours Cooling, Total	7,497,831
Annual Ton Hours BCHP Cooling	5,883,678
Annual Ton Hours Electric Cooling	1,614,153
Elec net kW peak export to grid	0
Annual kWh Produced by G.Turbine Gen.	10,571,742
Annual Heating MMBtu Savings Total	0
Process Heating as % of Space Heating	25.00%

at 5.50% dscnt rate

Debt to Investment Ratio	100.00%
Income Tax Rate %	0.00%
Annual Interest Rate %	0.00%

Project Schedule and Key Milestones

Project Schedule and Key Milestones

Completed:

- Site selected for project – January 2003
- Installation cost estimate – March 2003
- D/B Contract – August 2003
- Site mobilization – September 2003
- Commence final design – September 2003
- Task 2 Report submitted – November 2003

Project Schedule and Key Milestones

Planned:

- System design complete – Dec 2003
- Turbine & Chiller installed – Feb 2004
- BOP & Controls installed – April 2004
- Installation complete – May 2004
- Commissioning – June 2004
- Testing complete – Fall 2004
- Submit final report – December 2004

Expanding the BCHP Team

Collaborating Organizations

- The University of Texas, School of Engineering
- The University of Texas, LBJ School of Public Affairs

Summary

- Expect a strong positive impact on the BCHP program:
  - On track to meet DOE program goals
  - Cost share - 64% of total cost
  - Opportunity to address significant utility-related issues
  - Design will be replicable
  - Design can be sized for different applications
  - System has potential for widespread commercial implementation

Questions?

Thank You For Your Interest In Our Project